City of Sturgis Wastewater System Improvements
Summary of GPR Eligible Components
June 2012

Summary and Overview of the Project

Provisions of the *2010 Clean Water and Drinking Water State Revolving Fund 20% Green Project Reserve: Guidance for Determining Project Eligibility Guidance*, dated April 21, 2010, indicate that a number of project components in the Sturgis Wastewater System Improvements are eligible for "principal forgiveness", or a reduction in the loan capital amount.

As presented in the SRF Project Plan, originally submitted June 2012 and updated March 2013, the City of Sturgis (City) has committed to implement necessary improvements to the City's wastewater system. Improvements are necessary at the Wastewater Treatment Plant (WWTP) and within the collection system. The elements that qualify for Michigan's FY2012 *GPR* are located at the WWTP and at the Diesel Plant Lift Station.

The Recommended Alternative incorporates several GPR components that will provide environmental benefits beyond those typically achieved at wastewater collection and treatment facilities. The Recommended Alternative is in keeping with the City's commitment to provide continued reliable wastewater service while pursuing innovative, environmentally attractive, and cost effective technologies. The City embraces environmental Best Management Practices that surpass ordinary utility practices and further the goals of the Clean Water Act.

Pursuant to the criteria outlined in the Guidance, the recommended alternative exhibits *GPR* benefits through categorical energy efficiency, by:

1. Energy Efficiency: Improving production of renewable, clean energy by enhancing biogas production, and thereby reducing the consumption of fossil fuels by the WWTP, and the Diesel Plant Lift Station;
2. Energy Efficiency: Utilize "high efficiency" motors on new equipment where possible.

The City of Sturgis WWTP Project meets the definition of a "Categorical GPR Project" under the "Energy Efficiency" guidelines where,

> "Energy Efficiency is the use of improved technologies and practices to reduce the energy consumption of water quality projects, use energy in a more efficient way, and/or produce/utilize renewable energy."

This City of Sturgis project accomplishes all of the requirements of these definitions, as detailed below.

Biogas as a Source of Clean Energy

A project goal includes increasing energy generation by the WWTP anaerobic digestion process through the replacement of the headworks equipment. This will mitigate digester gas production inefficiencies resulting from fouling from rags and grit accumulations in the tanks and piping. These inefficiencies currently require higher consumption of utility-purchased natural gas and electrical power. As demonstrated below, the net improvement exceeds the 20 percent threshold standard for reduction in energy consumption and is thus categorically eligible for GPR.

Currently, the WWTP utilizes a high-rate anaerobic digestion process to stabilize biosolids (sludge) generated through the treatment process. The WWTP captures biogas generated though the process and utilizes it to fuel a boiler for maintaining the heat in the anaerobic digestion process. The energy production from this process has been reduced by digester fouling due to rags and grit accumulations, and the operating energy consumption has been

increased by grit. The digester energy production will be increased, and the energy consumption will be decreased by this project as follows.

The existing comminutor and circular grit unit are not effective at removing grit and rags either at high flow or low flow events. The existing circular grit collector has several manually operated flow control vanes. These vanes are adjusted to control flow distribution over the tank. The vanes are set for maximum grit capture at average daily flows, and allow organics to pass along to the primary clarifiers. The challenge with this equipment is that during low flows the organic and grit settle out too fast. Under high flows both grit and organics pass through the unit. Also, during the high flow events, grit is washed from the grit system to the primary clarifier where it settles and is pumped to the anaerobic digesters. The grit is pumped through the mixing and heating system creating additional wear on the equipment. Even though it was installed as part of the 2007 improvements project, much of the glass lining in the digester mixing pumps, piping and valves is worn away, indicating the grit problem is excessive.

In addition, material that is shredded in the comminutor can re-conglomerate once it is in the digester. The re-conglomerated material has clogged pipes, valves and equipment reducing the ability for the digester mixing and heating systems to maintain efficient operation. This lower efficiency reduces the gas output of the anaerobic digesters, increasing the natural gas required to maintain the temperatures.

A new headworks system that includes new screening and grit removal equipment is proposed to mitigate these issues. The proposed fine screen will remove rags and debris from the flow stream rather than simply grinding the material and passing it through to downstream equipment. This will mitigate the potential for re-conglomeration of rags and hair in the digester piping, allowing for more efficient operation.

The proposed grit removal system will have a higher capture rate, particularly for the fine, sandy type grit that the current system does not remove well. This will greatly reduce the amount of grit that is settling in the primary clarifier system, entering the digestion process, attacking the motive chopper pump and piping of the recirculation and mixing systems, and consuming additional mixing energy. The proposed grit system is designed to remove more grit, and perform effectively at all flow ranges. Currently grit is accumulating in the bottom of the digesters (primarily Digester #1) settling out and displacing useable digester volume. Pumping biosolids with high grit content requires the pumps to run longer to effectively mix the tank. Instead of running the mix pumps intermittently for a few hours per day, in order to accomplish adequate mixing, the digester mixing pumps need to run continuously. This is a tremendous waste of energy when the rags and grit would best be removed at the headworks of the WWTP.

The existing headworks motors and the digester mixing pump running continuously were compared to the proposed motor loads. A summary of calculations can be seen attached in Table 1. The overall electrical requirements at the plant are expected to decrease by 0.5% due to the reduced mixing requirements from removing the grit and rags.

The key to reliable biogas energy generation in these high rate digesters is effective mixing (i.e. contacting food and biomass) and heating (i.e. biomass maintaining high reaction rates). The increasing volume loading of "flushable wipes" (nonwoven fabric rags, see attached picture) has caused plugging of the digester chopper pumps, wrapping around the check valves and impellers followed by reduction in pipe velocity leading to complete system failure and regular need for labor-intensive cleaning and de-ragging.

Gas generation (when digester systems were clean and new) was 4,500 ccf (hundred cubic feet)/month, as shown in Table 2. Figure 1 shows the reduction to 2,800 ccf or less, occurred with ragging problems, and restoration to 4,000 ccf in January 2012 only after significant effort to remove the blockages. (Figure 2 shows a portion of the rags removed from the pump suction piping.) Refer to attached Figure 1 for information on the biogas generation. The biogas energy generated by the digesters is utilized to heat the digester. When there is not sufficient biogas

available, natural gas must be used in order to maintain the temperature in the digesters. The difference in biogas generation is approximately 1,326 million BTU per year (MMBTU/yr), or 1,100 CCF/month of natural gas. The increased efficiency of the biogas generation is estimated at 38%.

The proposed headworks fine screen will remove rags and "flushable wipes" thereby permanent improving the reliability of the digester biogas energy production. The proposed headworks grit removal system will alleviate the digester grit accumulation.

Calculations (refer to Tables 1 and 2, attached, for additional information)

Energy Reduction (Utility Purchased Natural Gas & Electricity)

Historic Best Biogas Energy = 3,510 MMBTU/yr (absent any rag/grit fouling in digesters)

Reduced Biogas Energy due to ragging/fouling = 2,184 MMBTU/yr

Estimated Biogas Energy Improvement = 3,510 MMBTU/yr - 2,184 MMBTU/yr
= 1,326 MMBTU/yr, or 38% Reduction
=388,600 kWh/yr, equivalent

Digester Mixing, Electrical Energy Required with grit = 188,000 kWh/yr

Digester Mixing, Electrical Energy Required without grit = 62,700 kWh/yr

Net Headworks, Electrical Energy Increase = 140,700 kWh/yr – 16,300 kWh/yr
= 124,400 kWh/yr (pumping, screening, et al)

Est. Electrical Energy Change = (188,000 – 62,700) – 124,400 = 900 kWh/yr Reduction

NET ANNUAL ENERGY REDUCTION = 388,600 + 900
= 389,500 kWh/yr, or 32% Reduction

The proposed headworks facility is necessary for the reliable operation of the WWTP processes and more specifically, making the anaerobic digesters and sludge holding processes energy efficient

In summary, the affected WWTP processes would see a 0.5% decrease in electrical requirements and a 38% increase in biogas generated due to reduced grit and ragging. The net energy savings of this improvement is estimated at 900 kWh/yr of additional loads (headworks pumping, screening, etc). The project unit processes would thus see a net increase in efficiency estimated at 389,500 kWh/year or 32%, making the project categorically eligible for GPR.

Energy Efficient Motors
All new motors for the screen and grit removal systems will be premium "High Efficiency" motors to reduce the electrical load of the new equipment.

Energy Efficient Lighting
All new lights at the Headworks Building and the replacement lights at the existing Grit Building will utilize energy efficient fixtures and lights.

Energy Efficient Windows
All new windows at the Headworks Building and the replacement windows at the existing Grit Building will utilize energy efficient frames and glass.

Diesel Plant Lift Station Efficiency Improvements

The Diesel Plant Lift Station project goals include reduction of the consumption of utility-purchased electrical power and improvement of pump performance. The net improvement exceeds the 20 percent threshold standard for reduction in energy consumption and is thus categorically eligible for GPR.

The existing Diesel Plant Lift Station utilizes 2 pumps (lead and standby) to pump wastewater. The existing pumps are 30 hp with an estimated 75% motor efficiency and a 72% pump efficiency. In addition, the existing VFDs are original electro-mechanical variable frequency drives from 1972. The existing VFDs and motors are inefficient. The proposed pump station will have motor starters and operate on an On-Off basis. This is estimated to reduce the overall runtime of the pumps and increase the efficiency. The existing pumps operate approximately 120 minutes per day while the proposed pumps will operate at an estimated 95 minutes per day. The proposed pumps will be high efficiency screw centrifugal pumps.

The new pumps will have premium "High Efficiency" motors with a nominal efficiency of 92% and a pump hydraulic efficiency of 70%±, depending on the manufacturer.

The overall efficiency increase accounts for losses due to VFD inefficiencies, hydraulic inefficiencies running at ½ of full speed, and motor load inefficiencies running the existing pump below the full load speed. The wire-to-water efficiency is estimated to be increased by 23.8%±.

In addition to using a more efficient motor, the new pumps will significantly reduce the pump size and motor horsepower from 30 hp to 7.5 hp and accomplish a slightly improved forcemain scouring capability. See Table 3 attached for details.

SRF Components Qualifying for GPR

As noted above, this Project includes GPR eligible components including installation of new headworks facilities to improve digester operations and use of higher efficiency pumps, motors, and electrical gear at the Diesel Plant Lift Station. The total pre-design budgetary cost estimate for the GPR eligible components totals $2,809,000 including non-construction costs and contingency. Refer to the attached cost estimate Table 4 for a breakdown of the GPR components.

Potential Future GPR Eligible Improvements

Because the City is committed to sustainable and environmentally friendly design and operation, the City may look into other GPR components for future projects, including solar powered equipment, geothermal heating, and additional biogas uses (e.g. generating electricity onsite with excess biogas produced, heating buildings with biogas, and/or scrubbing the biogas to utility grade and selling it a local utility company).

Figure 1 - Biogas Generation

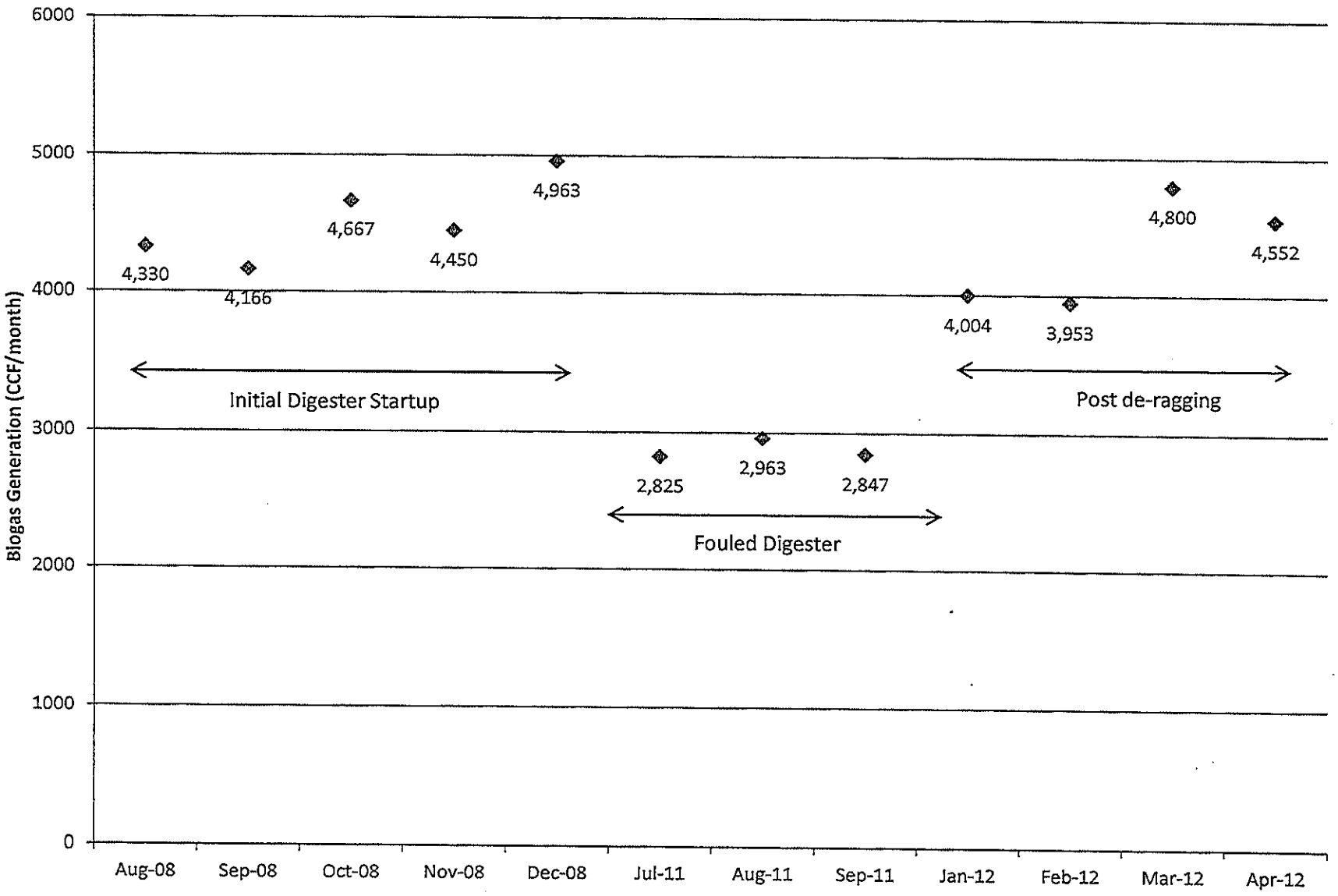

FIGURE 2 – RAGS REMOVED FROM DIGESTER PIPING

Table 1 - Annual Electrical Energy Increase Due to Grit Buildup

Existing Electrical Loads	Motor BHP	Run time (Hours/day)	Run time (Hrs/yr)	Electrical Usage (kWh/yr)
Ex. Grit Collector	0.5	24	8,760	3,266
Ex. Grit Conveyor	0.5	24	8,760	3,266
Ex. Organics Pump	0.5	24	8,760	3,266
Ex. Comminutor	1	24	8,760	6,532
			Subtotal	16,331
Ex. Digester Mixing Pump (w/ grit)	28.8	24	8,760	188,003
			Total	**204,334**

Proposed Electrical Loads	Motor BHP	Run time (Hours/day)	Run time (Hrs/yr)	Electrical Usage (kWh/yr)
Screw Pump	16.4	24	8,760	107,106
Grit Pump	3.77	24	8,760	24,627
Screen	0.5	6	2,190	817
Washer/Compactor	1	6	2,190	1,633
Grit Fluidizing Pump	0.5	24	8,760	3,266
Grit Classifier	0.5	24	8,760	3,266
			Subtotal	140,715
Ex. Digester Mixing Pump (Normal Operation)	28.8	8	2,920	62,668
			Total	**203,382**

Table 2 - Annual Gas Energy Savings (Digester Heating)

	Gas Production (CCF monthly)	Equivalent Natural Gas (CCF/month)	Annual Biogas Heat Energy (MMBTU)	Annual Biogas Energy (kWh equivalent)
Normal, Best	4,500	2,925	3510	1,028,722
Reduced (Ragging)	2,800	1,820	2184	640,094
Improvement/Savings	**38%**	**1,105**	**1,326**	**388,628**

Table 3 -Diesel Plant Lift Station Pump Efficiency

	Existing	Proposed
Motor HP	30	7.5
Motor Efficiency	75%	92%
Load Cell	95%	-
VFD Load Cell	90%	-
VFD Motor Inefficiency	90%	-
Pump Efficiency[1]	72%	71%
Wire to Water Efficiency	41.6%	65.3%
Increased Efficiency	**23.8%**	

[1]Existing pump efficiency is likely lower due to reduced speed of pump, further increasing the overall wire to water efficiency

TABLE 4

City of Sturgis

SRF Project Plan - Wastewater System Improvements

Green Project Reserve - Component Summary

Opinion of Probable Project Cost **

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ENGINEERING, INC.
Offices in Michigan and Indiana
2960 Lucerne Drive S.E., Grand Rapids, MI 49546
Office (616) 977-1000 Fax (616) 977-1005

Project No.:	810420
By:	DCH
Date:	June 13, 2012
Updated:	March 29, 2013

Item	Item Description	Unit	Quantity	Estimated Unit Price	Estimated Amount
Improvements Common to All Alternates					
Diesel Plant Lift Station Improvements					**$225,500**
1	Demolition of Existing Lift Station	LS	1	$ 5,000	$5,000
2	Bypass Pumping During Construction	Month	1	$ 26,000	$26,000
3	Excavation and Backfilling	LS	1	$ 5,000	$5,000
4	Lift Station Reinforced Concrete Top Slab	LS	1	$ 15,000	$15,000
5	Rehab Wetwell Interior	LS	1	$ 20,000	$20,000
6	Valve Chamber	LS	1	$ 6,000	$6,000
7	Valves and Piping	LS	1	$ 26,000	$26,000
8	Hatches	Each	3	$ 3,000	$9,000
9	Pumps and Guiderails	LS	1	$ 67,500	$67,500
10	Electrical Control Panel & Telemetry	LS	1	$ 45,000	$45,000
11	Surface Restoration	SYD	500	$ 2.00	$1,000
Alternate 5.3- WWTP Surge Basin- Screen/De-Grit Peak Flows					**$30,000**
1	Upsizing Fine Screen & Grit Systems	LS	1	$ 30,000	$30,000
Alternate 6.2- Screw Pumps					**$373,000**
1	Screw Pumps	Each	2	$ 76,000	$152,000
2	Reinforced Concrete	CYD	100	$ 700	$70,000
3	Slide Gates	Each	3	$ 12,000	$36,000
4	Grating & Miscellaneous Metals	LS	1	$ 55,000	$55,000
5	Electrical Control & Instrumentation	LS	1	$ 60,000	$60,000
Alternate 7.2- East Headworks					
Headworks East of Existing					**$1,247,600**
1	Excavation and Backfilling	CYD	550	$ 30	$16,500
2	Reinforced Concrete	CYD	190	$ 700	$133,000
3	Block Building (≈37'-4" x 32' x 12' H)	SF	1,190	$ 160	$190,400
4	Fine Screen-Equipment	Each	1	$ 225,000	$225,000
5	Grit Removal-Equipment	Each	1	$ 250,000	$250,000
6	Fine Screen & Grit - Installation	LS	1	$ 142,000	$142,000
7	Plumbing & HVAC System	LS	1	$ 60,000	$60,000
8	Parshall Flume	Each	1	$ 10,000	$10,000
9	Grating, Stop Plates & Miscellaneous Metals	LS	1	$ 50,000	$50,000
10	Reroute 12" Forcemain from Fawn River PS	Feet	70	$ 55	$3,900
11	Reroute 14" Forcemain from FRC Pump Station	Feet	140	$ 60	$8,400
12	24" Influent Sanitary Sewer	Feet	220	$ 120	$26,400
13	24" Process Sewer to Flow Splitter	Feet	200	$ 120	$24,000
14	Manholes	Each	4	$ 4,500	$18,000
15	Shoring	LS	1	$ 15,000	$15,000
16	Electrical Installation	LS	1	$ 75,000	$75,000
				Construction Subtotal (Rounded):	$1,876,100
	Contractor Mob/Demobilization, General Conditions (5%)				$93,800
				Construction Subtotal (Rounded):	$1,969,900
	Contingencies (~10% of Construction Subtotal)				$200,000
	Financial Advisory, Legal, Trustee Fees & Administrative Expenses (5%)				$108,000
	Land, Structures, Right-of-Ways, Appraisals, Easements, etc				$0
				SRF Project Plan	$43,400
	Architectural & Engineering Design Fees (10%)				$269,900
	Resident Project Representative Fees (10%)				$217,000
	Total Estimated Selected Alternative Project Cost (rounded):				**$2,809,000**

Notes:

** The Design Professional has no control over costs or the price of labor, equipment or materials, or over the Contractor's method of pricing. Bid prices may vary significantly based on these factors and market conditions at time of bid.